THE THEORY OF
RELATIVITY HAS BECOME
WIDELY KNOWN, BUT
IT WOULD BE RASH
TO SAY THAT IT HAS
BEEN WIDELY UNDERSTOOD

— John Stachel.

ARGUMENTS AGAINST TACHYONS (T)

IP = Invariance Principle
PIP = philosophically-grounded version of IP.
FSP = First Signal Principle

(1) Einstein's Argument

$$IP \rightarrow FSP$$
$$T \rightarrow \sim FSP \rightarrow \sim IP$$

(2) Grünbaum's Argument

$$PIP \rightarrow FSP$$
$$T \rightarrow \sim FSP \rightarrow \sim PIP$$

(3) Causal Paradox Argument

$$IP \wedge T \rightarrow \text{contradiction}$$
$$\therefore\ T \rightarrow \sim IP$$

or $IP \wedge T \wedge S \rightarrow$ contr.

$$\therefore\ T \rightarrow (\sim IP) \vee \sim S$$

where S = Tachyon Signal Hypothesis

ENERGY AND MOMENTUM OF A TACHYON

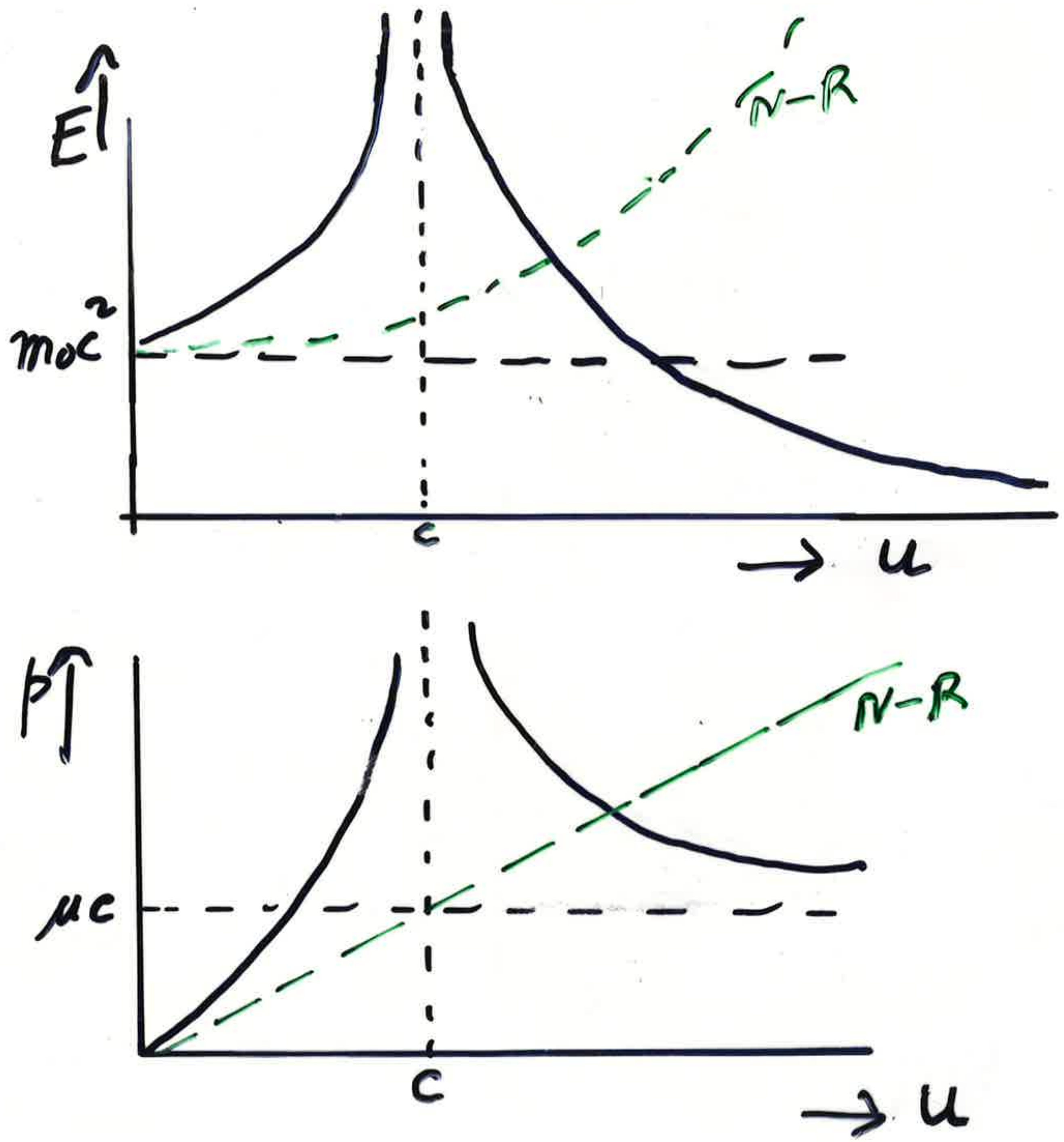
For Bradyons

$$E = \frac{m_0 c^2}{\sqrt{1 - u^2/c^2}}, \quad \underset{\sim}{p} = \frac{E\underset{\sim}{u}}{c^2}$$

For Tachyons $m_0 \to i\mu$

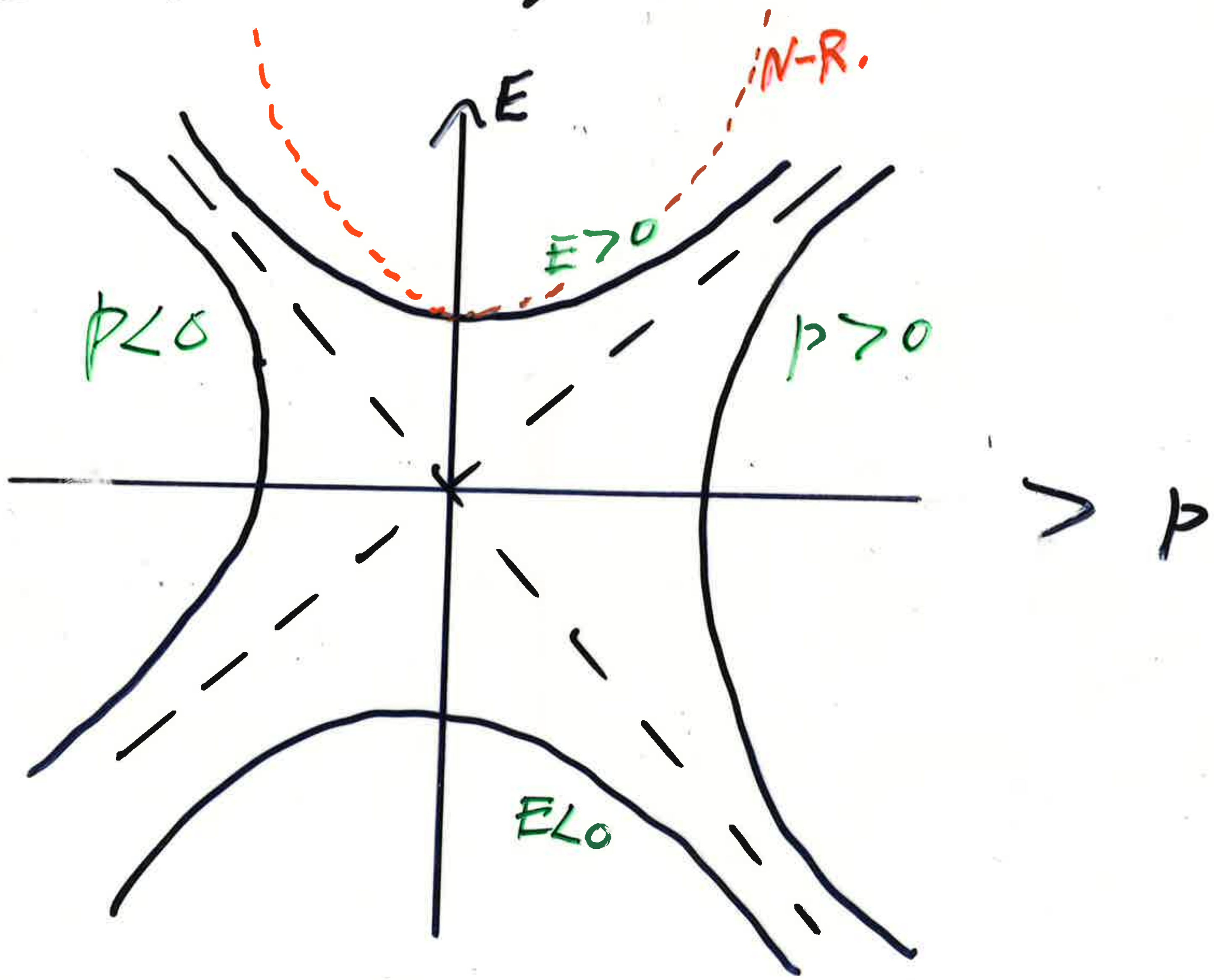
So

$$E = \frac{\mu c^2}{\sqrt{u^2/c^2 - 1}}, \quad \underset{\sim}{p} = \frac{E\underset{\sim}{u}}{c^2}$$


E
m_0c^2
N-R
c
→ u
p
μc
N-R
c
→ u

$$E^2 - p^2c^2 = m_0^2c^4 \qquad u < c$$

$$E^2 - p^2c^2 = -\mu^2c^4 \qquad u > c$$



N.B. $u = \dfrac{dE}{dp}$

ENERGY AND TIME-ORDER CHANGE SIGN TOGETHER ON A TACHYON TRAJECTORY

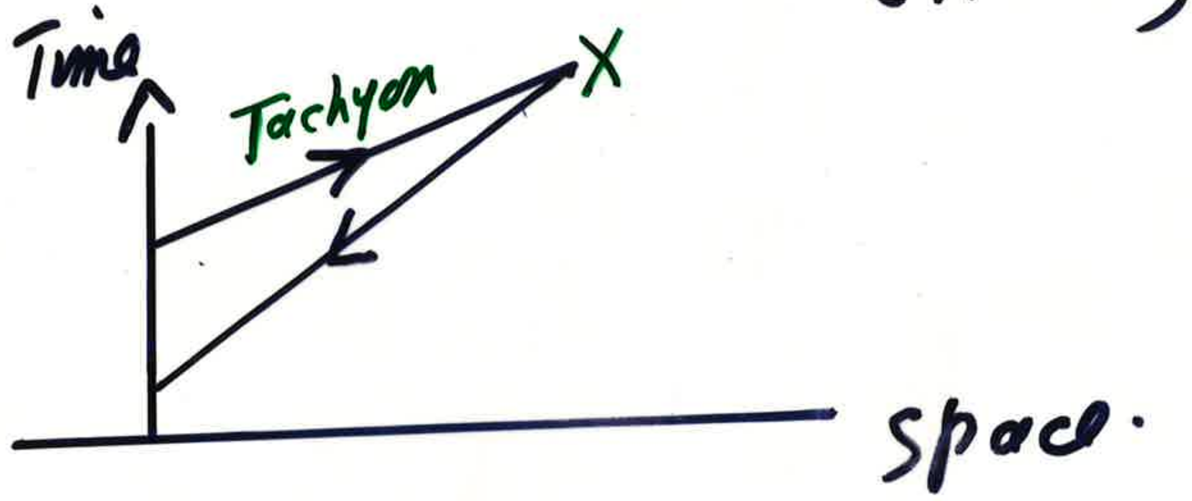
$$E' = \frac{E}{\sqrt{1-v^2/c^2}}\left(1 - \frac{v u_x}{c^2}\right)$$

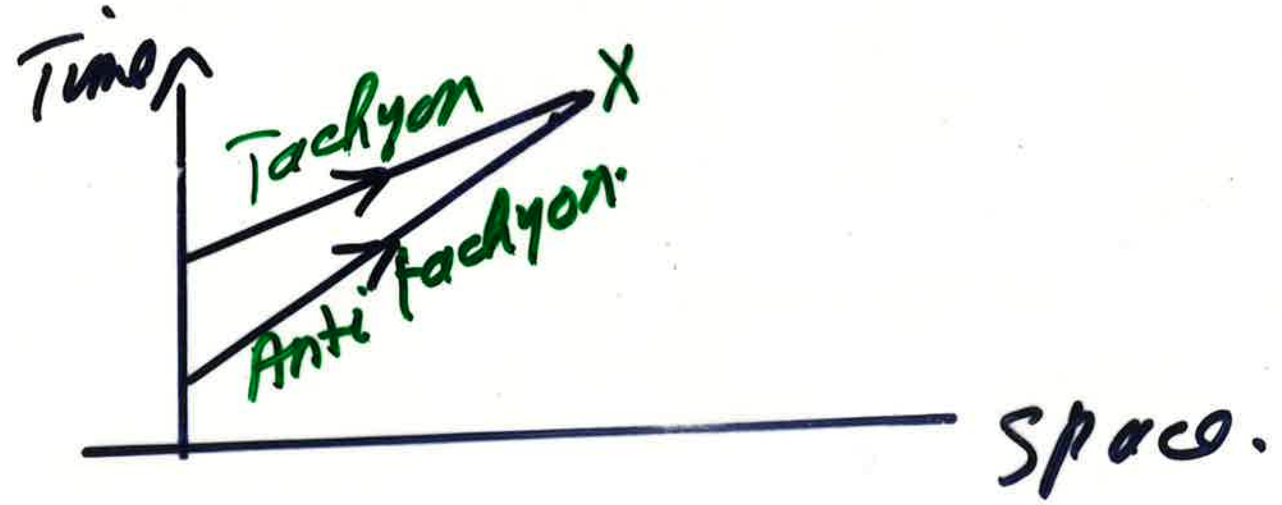
changes sign when $v > \frac{c^2}{u_x}$

$$t_2' - t_1' = \frac{t_2 - t_1}{\sqrt{1-v^2/c^2}}\left(1 - \frac{v u_x}{c^2}\right)$$

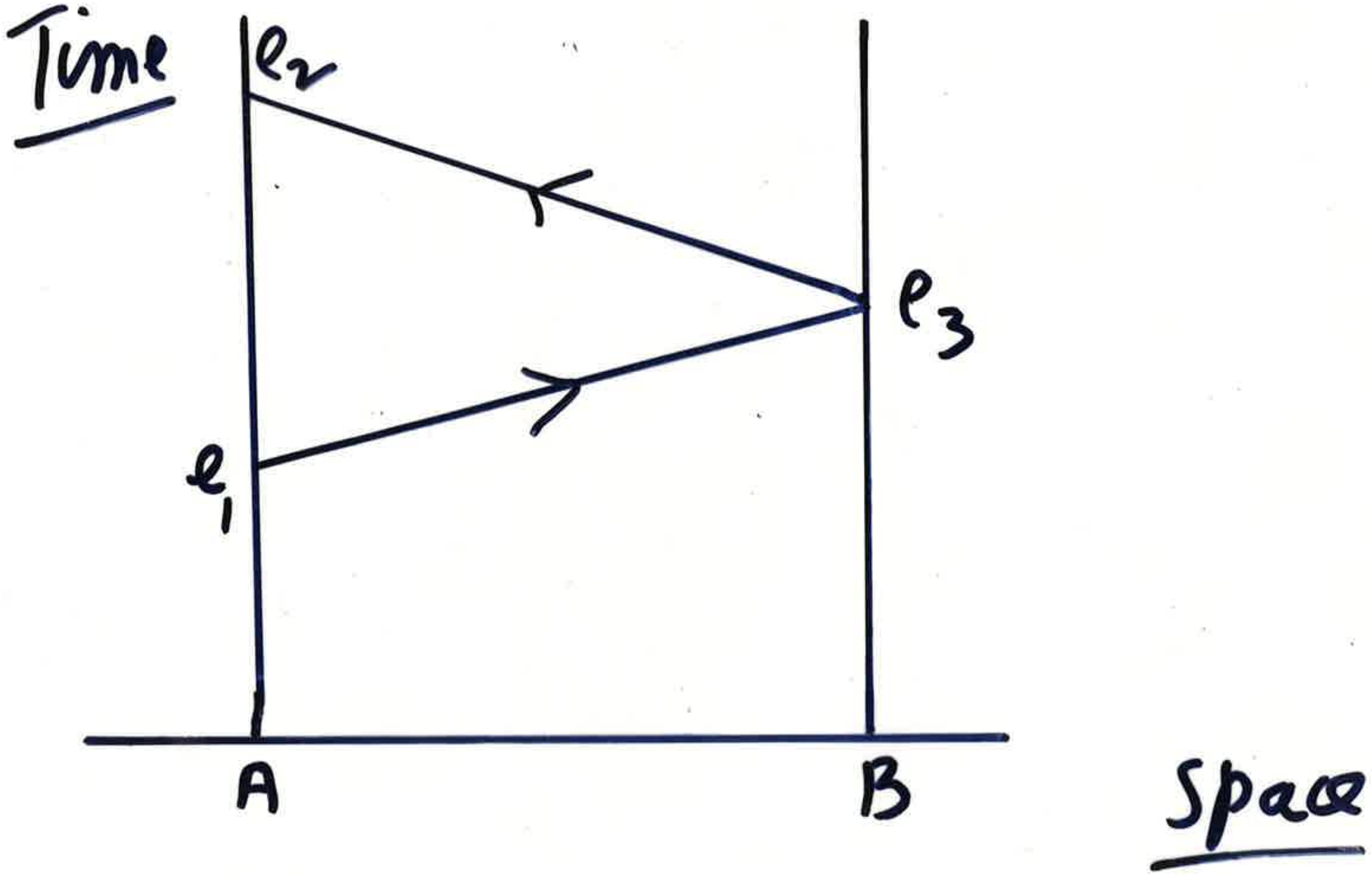
also changes sign when $v > \frac{c^2}{u_x}$

THE REINTERPETATION PRINCIPLE (RIP)

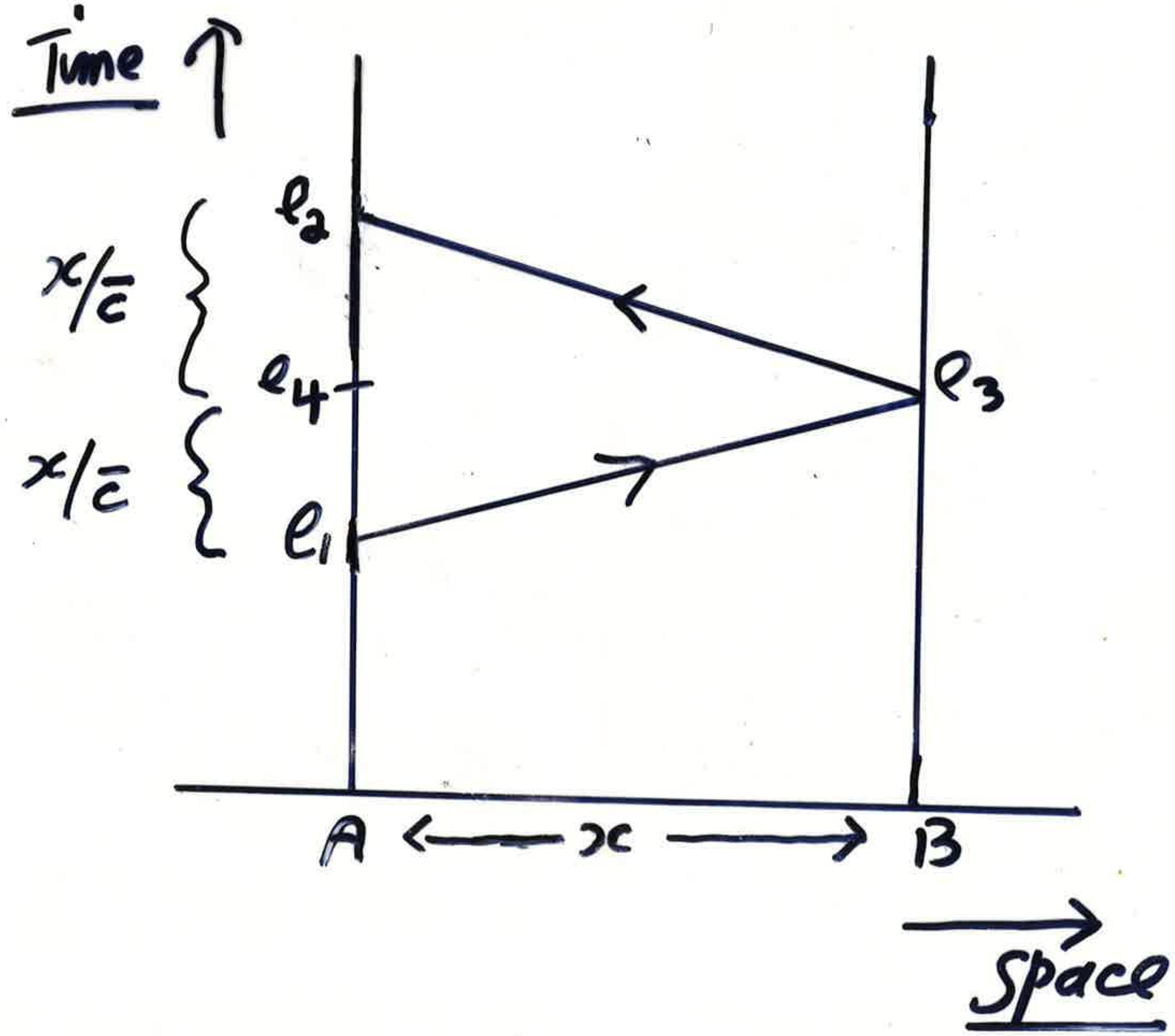




CONVENTIONALITY OF SIMULTANEITY



CONVENTIONALITY OF SIMULTANEITY. contd



G = variable ranging over complete genidentical sets

S = variable ranging over continuous genidentical sets

so $\forall S \exists G \, (S \subseteq G)$

We write $e_1 \in G \wedge e_2 \in G \wedge \ldots$ as $G(e_1, e_2 \ldots)$

<u>Betweenness</u>

$e_3 B e_1 e_2$ iff $\exists G \, [G(e_1, e_2, e_3) \wedge \forall S \, (S \subseteq G - \{e_3\} \rightarrow \sim S(e_1, e_2))]$

<u>Simultaneity</u>

$e_3 \int_R e_4$ iff $\forall e_5 \forall G \, (\sim G(e_3, e_4, e_5))$.

(6a)

THE FIRST SIGNAL PRINCIPLE

$$\exists e_1 \exists e_2 [e_3 \underline{B} e_1 e_2 \wedge \forall e_4 (e_4 \underline{B} e_1 e_2 \rightarrow e_3 S_R e_4)]$$

Cp Grünbaum's defn of Simultaneity

$$e_3 S_G e_4 \text{ iff } \forall G (\sim G(e_3, e_4))$$

N.B $e_3 S_G e_4 \rightarrow e_3 S_R e_4$

THE REICHENBACH ε- PARAMETER

$$t_3 = t_1 + \varepsilon(t_2 - t_1)$$

$$0 < \varepsilon < 1$$

$$\vec{c} = \frac{x}{t_3 - t_1} = \frac{\bar{c}}{2\varepsilon}$$

$$\overleftarrow{c} = \frac{x}{t_2 - t_3} = \frac{\bar{c}}{2(1-\varepsilon)}$$

where $\bar{c} = 2x/t_2 - t_1$

with $\varepsilon = \frac{1}{2}$, $\vec{c} = \overleftarrow{c} = \bar{c} = c$

TRANSFORMATION BETWEEN MOVING REFERENCE FRAMES

$$\left.\begin{aligned} x' &= Ax + Bt \\ t' &= Ct + Dx \end{aligned}\right\}$$

For $x' = 0$, $x = vt$ so $B = -Av$

Define $m = -D/C$

Then
$$\left.\begin{aligned} x' &= A(x - vt) \\ t' &= C(t - mx) \end{aligned}\right\}$$

Now suppose moving rod is contracted by a factor F and a moving clock is dilated by a factor $\underline{G}$

Then $A = 1/F$

$$C = \frac{1}{G(1-mv)}$$

So
$$\left.\begin{aligned} x' &= \frac{1}{F}(x - vt) \\ t' &= \frac{1}{G(1-mv)}(t - mx) \end{aligned}\right\}$$

$t' = 0$ has locus $t = mx$ in K

so m is the slope of the

<u>line of simultaneity</u>

ACOUSTIC SYNCHRONIZATION

$$U_x' = A/c \; \frac{U_x - v}{1 - m U_x}.$$

Put $U_x = \pm \omega$ and equate magnitudes of U_x'

$$\Rightarrow \quad m = v/\omega^2$$

So

$$\left.\begin{aligned} x' &= 1/F\,(x - vt) \\ t' &= \frac{1}{G(1 - v^2/\omega^2)}\left(t - \frac{vx}{\omega^2}\right) \end{aligned}\right\}$$

ACOUSTIC RELATIVITY

Newtonian world $F = G = 1$

so

$$x' = x - vt$$

$$t' = \frac{1}{1 - v^2/w^2}\left(t - vx/w^2\right)$$

(Zahar 1977)

Einsteinian world $F = 1/G = \sqrt{1 - v^2/c^2}$

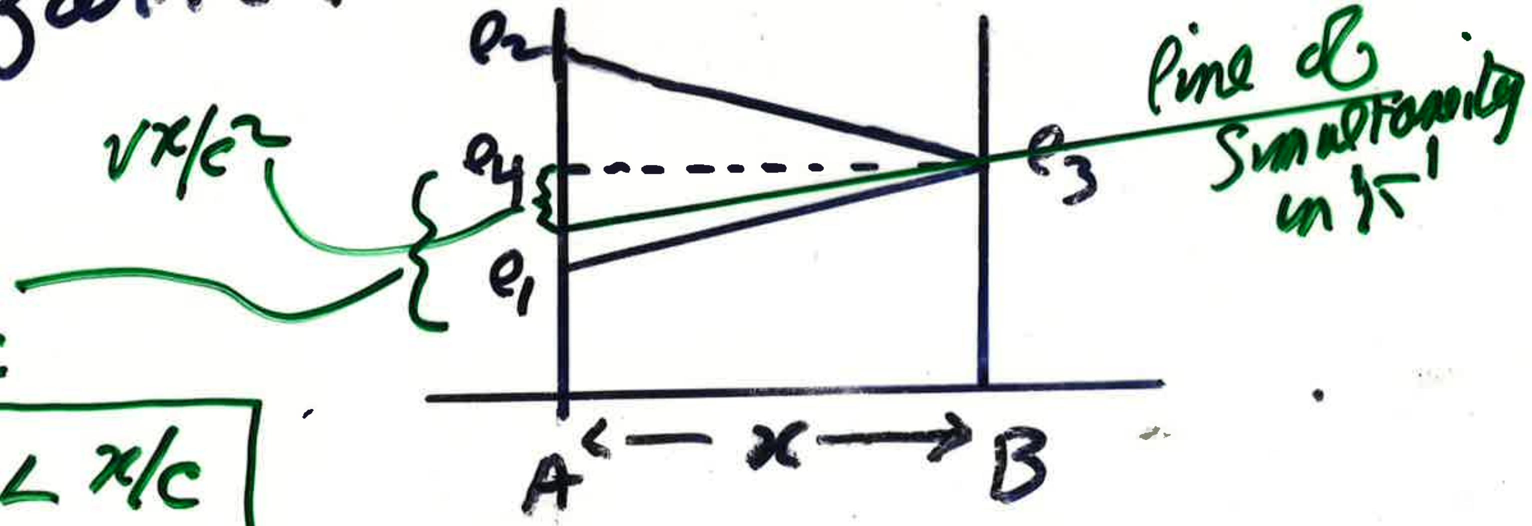
$$x' = \frac{1}{\sqrt{1 - v^2/c^2}}\left(x - vt\right)$$

$$t' = \frac{\sqrt{1 - v^2/c^2}}{1 - v^2/w^2}\left(t - vx/w^2\right)$$

BIZARRE SYNCHRONIZATION

A choice of synch. in K' is said to be bizarre if it makes metrically simultaneous in K' events which are not topologically simultaneous in K.

THEOREM The Einstein Convention for optical Relativity is never bizarre.



$vx/c^2 < x/c$
if $v < c$

Theorem

The Einstein Convention for Acoustic Relativity is bizarre for

$$v > \left(\frac{\omega}{c}\right) \cdot \omega$$

(i.e. when $\frac{v x}{\omega^2} > \frac{x}{c}$)

ε- RELATIVITY

$$x'' = x'$$
$$t'' = t' + \frac{x'}{w'}(2\varepsilon - 1)$$

So
$$x'' = \frac{1}{\sqrt{1-v^2/c^2}}(x - vt)$$

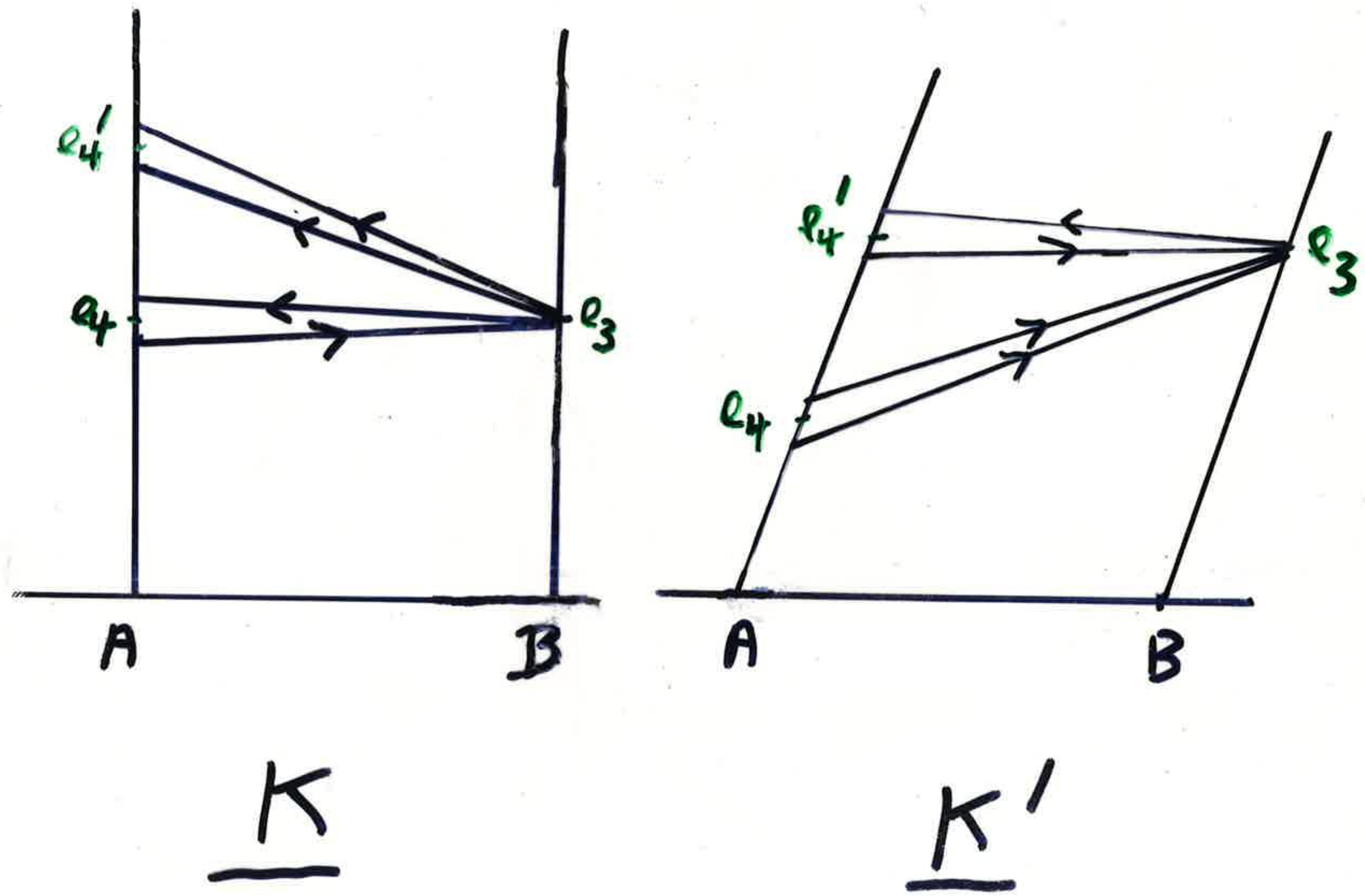
$$t'' = \frac{\sqrt{1-v^2/c^2}}{1-v^2/w^2}\left[t\left(1 - v/w\,(2\varepsilon-1)\right) + x/w\,(2\varepsilon - 1 - v/w)\right]$$

To eliminate relativity of simultaneity choose $\varepsilon = \frac{1}{2} + v/2w$.

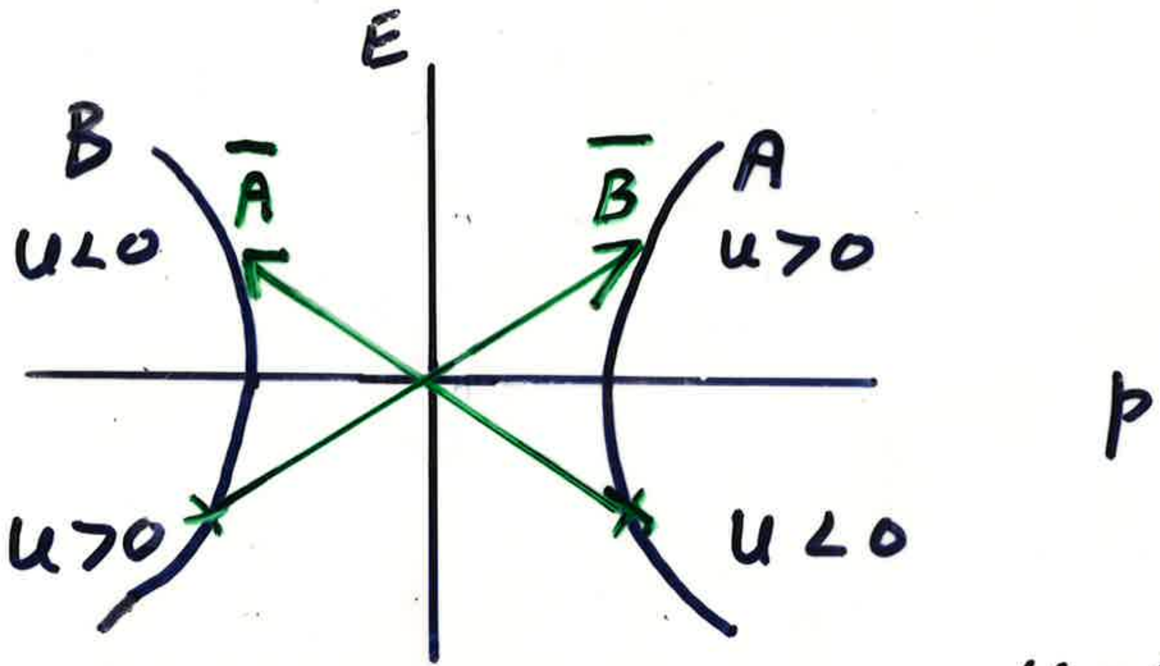
THE SJÖDIN – TANGHERLINI TRANSFORMATION

$$\left.\begin{aligned} x'' &= \frac{1}{\sqrt{1-v^2/c^2}}\,(x - vt) \\ t'' &= \sqrt{1-v^2/c^2}\cdot t \end{aligned}\right\}$$

TACHYON SYNCHRONIZATION



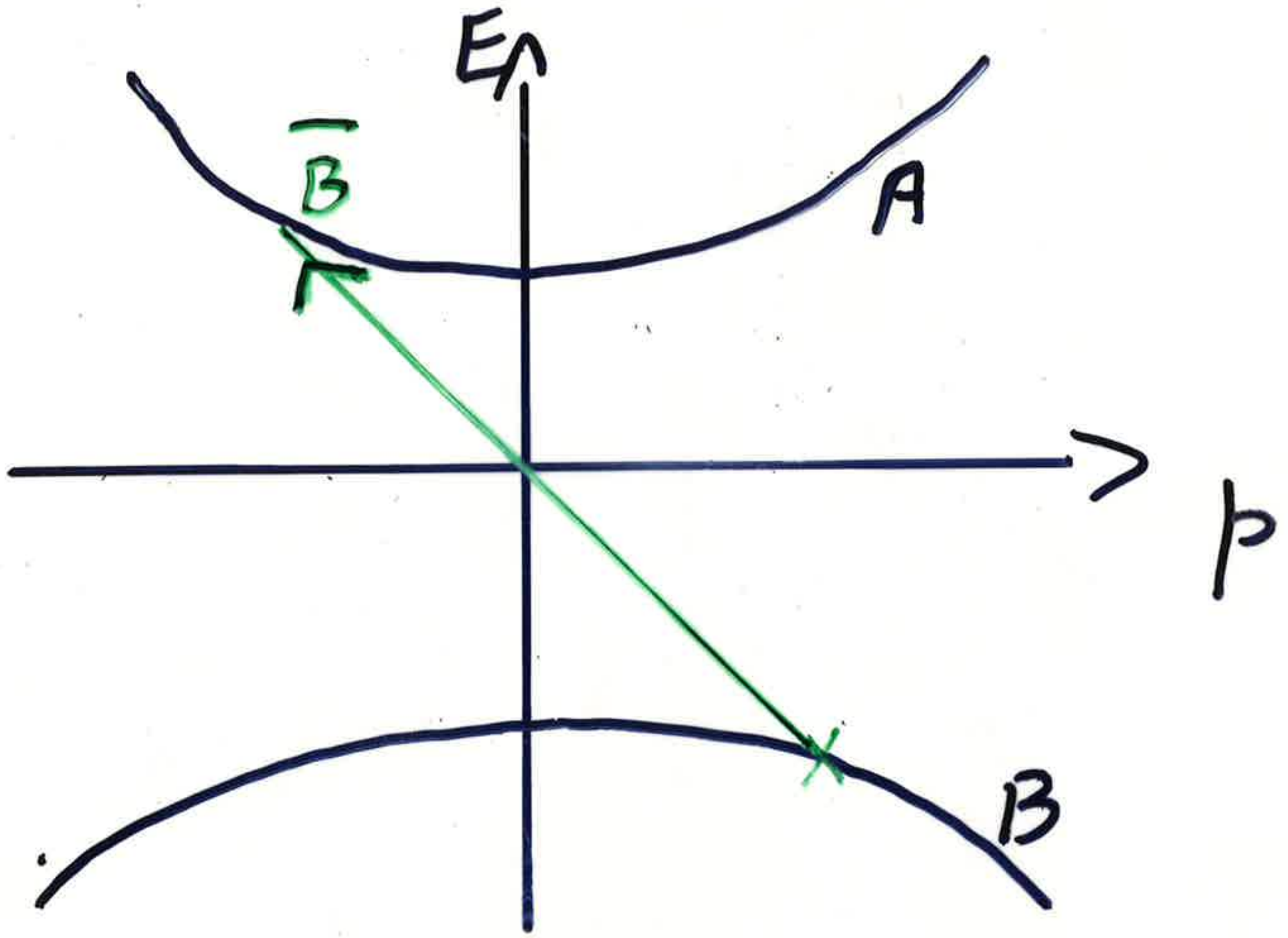
ONE-DIMENSIONAL TACHYONS



$u = \frac{dE}{dp}$

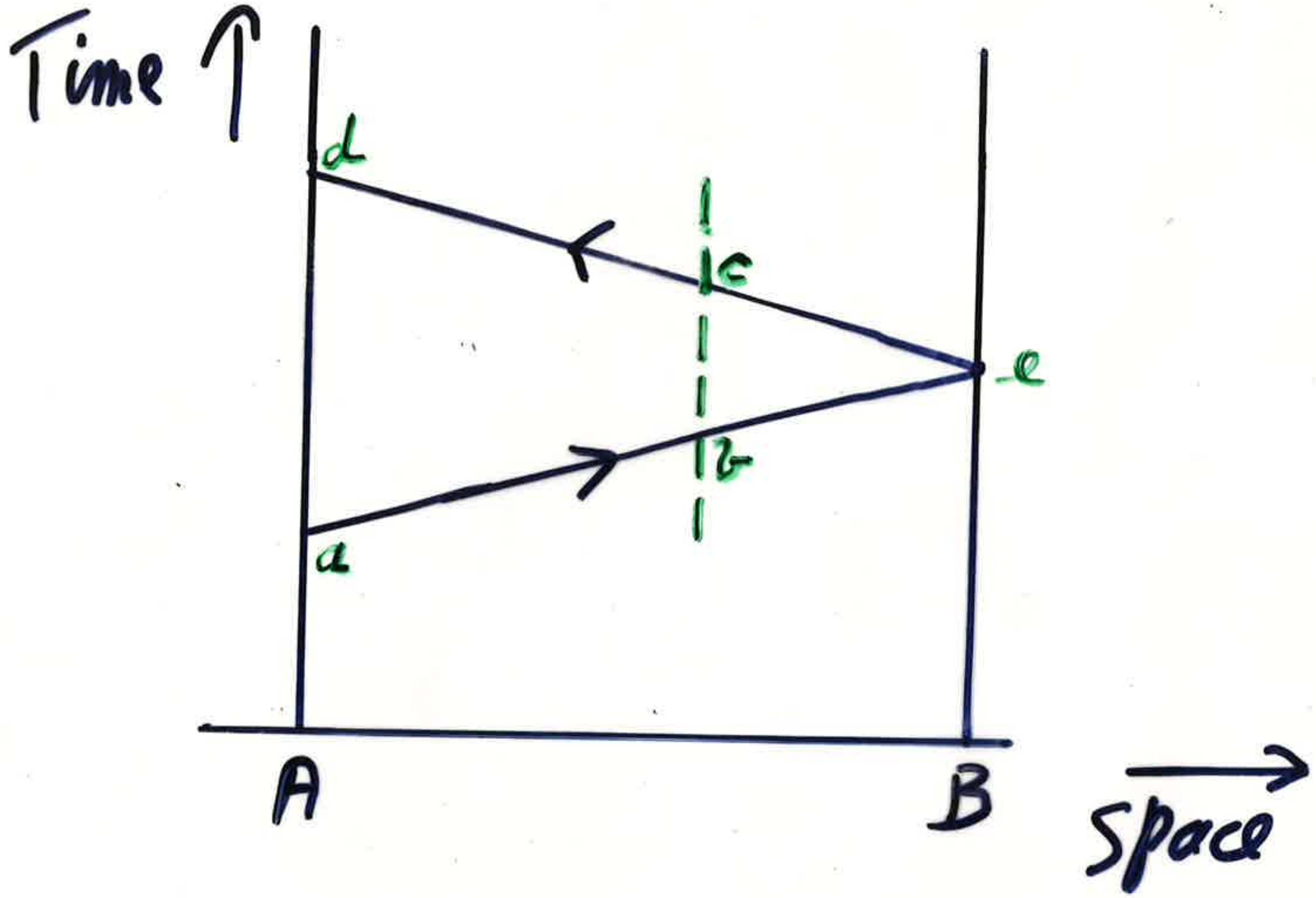
Particles moving to the right are $A, \bar{B}$
" " " " left " $B, \bar{A}$

BRADYON ANTIPARTICLES



Particles moving to the right are $A, \bar{B}$

" " " " left " $A, \bar{B}$



GENIDENTITY AND SPATIO
- TEMPORAL CONTINUITY